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RESEARCH PAPER

Consumption and species preference for house construction wood in central highlands of Ethiopia – implications for enhancing tree growing

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Abstract: A study was conducted in central Ethiopian highland in 2008 to investigate the consumption of house construction wood, the tree species preference for construction wood and the forthcoming conditions of this forest product and possible strategies for future availability. Twenty-four iron-roofed houses and twenty-eight thatch-roofed houses belonging to thirty-six farm households were investigated for types, volumes and sources of construction wood used. It was found that an average farmhouse with a floor space of 57 m^2 consumed about 13.7 m^3 of wood. Both floor space and wood consumptions vary with house types. An average iron-roofed house with floor space of 51.9 m^2 consumed 16.8 m^3 of wood and an average thatch-roofed house with mean floor space of 28.6 m^2 consumed 3.2 m^3 of wood. Family size and floor space were the major factors influencing construction wood consumption. An average living house was composed of woods of 39.3% *Juniperus procera*, 5.6% *Cupressus lusitanica*, 29.2% *Eucalyptus globulus* and 26% *Eucalyptus camaldulensis*. The wood volume from the first two species and half that of the third species were obtained from state forest which is currently banned from any construction wood extraction and hence there is a shortage of around 59.5% of woods. We suggest the promotion of various tree planting approaches to increase the wood supply and the use of alternative local materials like soil bricks for house construction.

Keywords: construction wood; floor space; iron-roofed house; thatch-roofed house; species preference

Introduction

Housing is one of the basic necessities of life for humans (United Nations 1948). However, the provision of shelter is one of the pressing challenges faced by the third world countries in the 21st century (Tiwari 2001; Wells et al. 1998) for two main reasons: the increase in human population and the severe degradation of forest resources (Wells et al. 1998) in these countries.

Timber is the major part of houses in sub-Saharan Africa. In Ethiopia, 96% of the rural houses are composed of organic materials like timber, bamboos, grasses, leaves and agricultural residues (Wells 1995). In central highlands of Ethiopia, only timber and thatch grasses are used. Iron sheets and thatch grasses are used as roof covers dominantly.

Timber and poles are obtained from forests (natural and/or plantation). Forests, in general were the basic sources of construction wood (Thomas et al. 2003). However, the severe depletion of Ethiopian forest resources (currently below 2.7% of the land cover according to EARO (Ethiopian Agricultural Research Organization) (2002)) and population increment (Duguma et al. 2009a; Aregu et al. 2006, Jagger et al. 2003) are resulting in the overall scarcity of forest products (Duguma et al. 2009b).

Numerous factors such as the wealth status of a household and family size influence the extraction of forest products from forests. Various studies have indicated that wealth status has a vital role in determining the environmental resources extraction of a household. For example, Mamo et al. (2008) in Ethiopia, Escobal et al. (2003) in Peru, and Cavendish (2000) in Zimbabwe showed that rich households extract larger quantity of forest products than the poor ones. A contrasting result from India by Narain et al. (2008) indicates that both the rich and the poor were highly dependent on forests than the medium ones. The authors further stated that the dependence for construction wood increases with household income for the whole community.

Adhikari et al. (2004) showed that family size is an important household characteristic for extracting forest resources. The larger the family size is, the more they extract and utilize forest products from forests. However, not all big families have sufficient labour to do so as there could be high dependency ratio if there are many old or many young people in the family. In relation to the labour issue, the distance to the forest is also a very important factor because it is easy for the family nearer the forest

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to extract the forest products.

The types of wood used, preferred species and the supply source potential and its future condition altogether determine the house construction wood situation in an area. These issues vary depending on the place because every place has its own social, climatic, and biotic characteristics, which determine the type and size of houses, the type of tree species growing in the specific area, the soil type and other important characteristics that influence house construction. National level data and files, thus, are not very reliable due to the aforementioned variability by locality. Banks et al. (1996) also stated that national or regional figures may not really express the reality at local levels. Therefore, it is very vital to have local level information to describe more accurately the current and future conditions regarding house construction. In general, there is little information regarding rural house construction in Ethiopia. Even the existing studies mainly focus on urban situations, masking the information concerning rural housing. Wall et al. (1998) also mentioned that there is scanty of information on construction wood and in addition, the statistical approaches are weak.

The objectives of this study were thus: 1) to determine the wood consumption for house construction and factors influencing it; 2) to investigate the tree species preference for various components of house and; 3) to elicit the future situation of house construction wood and recommend possible copping mechanisms.

Materials and methods

Study area

The study was conducted in Suba area, Welmera district, Oromia regional state, Ethiopia in 2008. Suba is situated between N 8°56'–9°00', and E 38°31'–38°35' and has an average altitude of 2 330 m above sea level lying in central highlands of Ethiopia. The mean annual rainfall is 1056 mm and the mean minimum and maximum monthly temperatures are 6 and 22°C respectively based on weather data from a nearby station. The low altitude parts of the area are relatively flat while the high altitude parts have an undulating topography. The woodland vegetation is wholly devastated due to expanding agricultural activity, increasing wood consumption with rising human population and inconsiderate agricultural investments. The only forest in vicinity is Menagesha Suba state forest which is dominantly composed of *Juniperus procera* Hochst., *Podocarpus falcatus* Thunb., *Olea africana* Mill., *Prunus africana* Hook., *Hagenia abyssinica* Willd., *Cupressus lusitanica* Mill., and other tree and shrub species. The community is agrarian, mainly practicing crop production and small-scale livestock farms. Wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and teff (*Eragrostis tef* Zucc.) are the major crops grown.

In the rural part of Welmera district (including Suba), 34.2% of houses are roofed with corrugated iron sheet, 64.1% with thatch grasses and the rest with wood and mud (CSA (Central Statistical Authority of Ethiopia) 1996). Among all the houses, 20.7% of them have a separate kitchen room (in addition to the living room), 59.4% of them use a single room both for kitchen and living room, 5.5% own a living room and a separate kitchen used for cooking and resting place for domestic animals during the night and 14.4% have no separate kitchen at all (CSA 1996).

Data collection

Farm households in the study area were categorized into three wealth classes (rich, medium and poor) with the help of the local authorities by using criteria including land holding, livestock size and house type. From each wealth class, twelve households were randomly selected (totally 36 households for the three wealth classes). Accordingly, all houses owned by the selected households (24 iron-roofed houses and 28 thatch-roofed houses) were used in this study. The same farmers were also classified into insiders, border farmers and far outsiders based on proximity to a state forest. The insiders live inside the state forest area, the border farmers live in the boundary of the forest and the far outsiders live next to the border from the state forest area. We counted, measured top and bottom under bark diameter of every piece of wood and recorded the species of every woody component of the selected houses. The house construction wood does not include parts like window, door, and other wooden utensils. The volume of the construction wood was computed using the Smalian's formula (Equation 1) (Forest Service British Columbia 2007) which is used to estimate the volume of log when the difference between the top and bottom diameter is less than 30%.

$$V = \left(T^2 + B^2\right) * L * C \tag{1}$$

where, V stands for the volume of log (m³), T for the top diameter (cm), B for the bottom diameter (cm), L for the length of the log (m), and C for a constant 0.0001570796.

After the measurements, group discussion was held with ten randomly selected farmers about the future situation of construction wood, variability in consumption and sources of the wood.

Statistical analysis

The collected quantitative data was organized and fed into Statistical Package for Social Sciences for Windows (SPSS) version 15.0.0 software (SPSS Inc. 2006). The data was analysed using correlation analysis, one-way ANOVA and regression curve estimation. A correlation analysis was used to assess the strength of the association between the different house and household attributes that are related to construction wood and to find out the ones significantly correlating with it. The one-way ANOVA was used to assess the construction wood consumption variability among the different groups. The regression curve estimation was used to plot the relationship between the independent variables and the significantly correlated predictor variables. Using this approach we tried to develop a predictive model, which could help to estimate the construction wood demand of a given farm household. The p-values were given at 5% probability unless mentioned. The qualitative data was interpreted contextually to

support the quantitative data.

Results and discussion

Demographic properties of the sample households

The poor households had the minimum family size, compared to the other two wealth groups. This could have resulted in the minimum working power of the family leading to low productivity. The largest family size was observed in the medium farm households, which also exhibited the highest dependents ratio and the lowest active labor ratio (Table 1).

Table 1. Demographic characteristics of the sample households

Household attributes	Poor	Medium	Rich	All households (n=36)
Family size (number)	4.9	6.2	5.6	5.6
Dependent ratio (%)	40.9	62.5	43.9	49.1
Active labor (%)	59.1	37.5	56.1	50.9
Male proportion (%)	44.0	56.2	44.5	48.2

Notes: Dependent ratio is the proportion of people in the family younger than 15 years and older than 65 years. Active labor ratio is the proportion of people in the family from 16–64 years in Ethiopian case.

Types of rural farmer houses

Houses are constructed in two types depending on the roofing material used, which are iron-roofed houses and thatch-roofed houses. Iron-roofed houses are often built in rectangular or square shape with the roof inclining some degree to the ground to allow the easy flow of rainwater. Similarly, thatch-roofed houses are built in rectangular, square or circular shape with the roof resembling a suspended cone. In both house types, the wall is constructed of wood. Every house built in the study area has six main components. Those are thin poles (*Maagara*), long poles (*Laaxaa/Waraajii*), very thin long poles (*Axanaa*), split wood (*Falaxaa*), posts (*Dhaabaa*) and huge centre pole (*Utubaa*). The first three parts compose the roof while the rest make up the wall. Split pole is a split of a thick pole into two major parts. The average renewal time for the wall is 27 years. The roof for the thatch-roofed houses is renewed every four years on average because of two major reasons. First, the roof carries a huge biomass especially the grass that commences to decay when exposed to rain. The heavy load thus, can lead to breaking down unless renewed at the right time. Second, some farmers use the old woods for the construction of thatch-roofed houses when they have the iron-roofed house. The old wood is very liable to rotting and decomposition and hence has to be renewed fast.

Thatch-roofed houses are further classified into major and minor houses depending on the presence or absence of iron-roofed houses. If there exists already an iron-roofed house, the thatch-roofed house is considered as minor house and it serves as kitchen, staying place for domestic animals at night and farm equipments store. If there is no iron-roofed house, the thatch-roofed house serves as the major house for living room, kitchen, farm tools store and a resting area for small domestic animals like calves, sheep, donkey and poultry. The group discussants explained that the type of wood used for the thatch-roofed house differs. Better wood, i.e. strong, thick and newly prepared ones, are used for major house while old, thin, simple and available woods are used for minor houses. Priority is always given for the major house.

Construction wood consumption by house components

The average floor space of a house owned by a farm household was 57 m^2, consuming about 13.7 m^3 wood (Table 2). However, there is a great disparity of the floor space and the wood consumption depending on the house types. It was found that the mean iron-roofed house built has a floor space of 51.9 m^2, consuming wood of 16.8 m^3 and the thatch-roofed house has a mean floor space of 28.6 m^2, consuming 3.2 m^3 wood. Major thatch-roofed houses (mean floor space is 38 m^2) had mean wood consumption of 4.6 m^3 while the minor (mean floor space is 21.6 m^2) consumes wood of 2.2 m^3. The floor space per square meter was found to consume wood of 0.32 m^3 and 0.11 m^3 for iron-roofed house and thatch-roofed house, respectively. This variability is attributed to the fact that iron-roofed houses have a vital role in determining the social status of the farmers in the community. Therefore, iron-roofed houses are often built with durable, strong and thick wood, which consume more wood than the thatch-roofed houses.

Table 2. Mean floor space and wood consumption by components of the farmhouses

House type	Mean floor space (m^2)	Mean wood volume (m^3)	Volume (m^3) by components					
			Maagara	*Laaxaa*	*Dhaabaa*	*Utubaa*	*Falaxaa*	*Axanaa*
Iron-roofed house	51.9 (7.0)	16.8(2.4)	1.3 (0.2)	1.3 (0.4)	4.2 (0.8)	0.01 (0.3)	9.4 (1.3)	0.6 (0.2)
Thatch- roofed house	28.6 (2.6)	3.2 (0.4)	0.1 (0.03)	0.6 (0.1)	0.5 (0.1)	0.1 (0.04)	1.6 (0.2)	0.4 (0.1)
All houses	57.1 (5.0)	13.7 (1.9)	1.0 (0.2)	1.3 (0.3)	3.2 (0.6)	0.1 (0.03)	7.5 (1.1)	0.6 (0.2)

Note: Numbers in the bracket represent the standard error of the mean.

Split wood *(Falaxaa*) and posts (*Dhaabaa*), which make up the wall of a house, constitute the largest proportions in house's

wood consumption (54.8% and 23.5% respectively). Though all the components are important in constructing houses, parts like center pole (*Utubaa*) and thin long poles (*Axanaa*) are only common in thatch-roofed houses.

House construction wood consumption by tree species

Only four tree species, *J. procera*, *C. lusitanica*, *Eucalyptus globulus* Labill. and *Eucalyptus camaldulensis* Dehnh. were found in the investigated farmhouses. Dharani (2002) reported that the first three species were used for construction in eastern Africa. *E. camaldulensis* is a very familiar tree species for construction wood especially in the mid and low altitude areas of Ethiopia.

Table 3. Average wood consumption of farmhouses by species

House type	Mean floor space (m^2)	Mean wood volume (m^3)	Volume (m^3) by species			
			J. procera	*C. lusitanica*	*E. camaldulensis*	*E. globulus*
Iron-roofed house	51.9 (7.0)	16.8 (2.4)	6.7 (2.2)	0.6 (0.3)	4.9 (1.3)	4.5 (1.0)
Thatch-roofed house	28.6 (2.6)	3.2 (0.4)	1.2 (0.3)	0.5 (0.1)	0.3 (0.1)	1.3 (0.3)
All houses	57.1 (5.0)	13.7 (1.9)	5.4 (1.5)	0.8 (0.2)	3.6 (1.0)	4.0 (0.7)

Note: numbers in the bracket represent the standard error of the mean.

An average living house wood was composed of 39.3% *J. procera*, 5.6% *C. lusitanica*, 26% *E. camaldulensis* and 29.2% *E. globulus*. However, the species composition of the living house wood varied with the type of house. For example, *J. procera* and *E. globulus* make up the majority (75%) of wood consumed by thatch-roofed houses while *J. procera*, *E. camaldulensis* and *E. globulus* compose above 95% of the wood used in iron-roofed houses (Table 3 and Fig. 1). In both house types, the contribution of *C. lusitanica* wood was minimal because the farmers only used it in times of scarcity as the wood is very susceptible to insect attack and decomposes easily when exposed to moisture. It was observed that with increasing altitude, the proportion of *E. globulus* wood in houses increased while that of *E. camaldulensis* decreased. This is attributed to the growing habit of the two tree species where the former performs well in higher altitudes while the later prefers lower altitudes. Thus, their growing position preference also limits the availability of the woods from the two species.

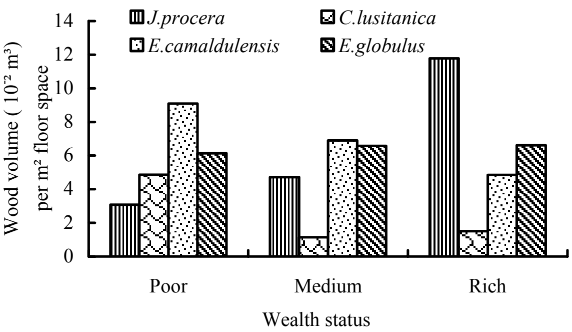

Fig. 1 Wood consumption of floor space per square meter based on species and wealth status

Tree species preference for various house components

The roofing wood materials (*Maagara*, *Laaxaa* and *Axanaa*) are composed of *E. globulus*, *E. camaldulensis* and *C. lusitanica* (Table 4). The wall part (*Dhaabaa*, *Utubaa* and *Falaxaa*) are composed of *J. procera* and *E. camaldulensis*. The other two species are only used in cases of scarcity. From the group discussions, it is identified that strength and weight of wood and resistance to insect and moisture are the basic criterion for selecting it for roof or wall. For roof, lighter but stronger wood like *E. camaldulensis*, *E. globulus*, and *C. lusitanica* are preferred. For wall, *J. procera* and *E. camaldulensis* are preferred as they are strong and resistant to moisture and insect attacks. The resistance and strength was associated with the large heartwood (which the farmers expressed as 'the red wood').

Table 4. Percentage of houses with the species used for various house components

Tree species	Woody components of house					
	Maagara	*Laaxaa*	*Dhaabaa*	*Utubaa*	*Falaxaa*	*Axanaa*
J. procera	25.0	22.2	77.8	16.7	41.7	11.1
C. lusitanica	22.3	25.0	2.8	0.0	30.6	30.6
E. camaldulensis[a]	33.3	13.9	19.4	5.6	33.3	13.9
E. globulus	72.2	75.0	13.9	13.9	44.4	61.1

Notes: Numbers in cells represent percentages of houses having the specified species for the respective house component. [a] Houses from the lower altitudes have results of 100%, 41.7%, 58.3%, 16.7%, 100%, and 41.7% for *Maagara*, *Laaxaa*, *Dhaabaa*, *Utubaa*, *Falaxaa* and *Axanaa*, respectively.

The volume of each species used in house construction is influenced by wealth status (Fig. 1). For example, the wealth status of the household significantly (p= 0.013) affected the total *J. procera* wood consumption, while it had no significant effect on the consumption of the other three species. The rich households used more *J. procera* wood than the poor ones (r = 0.5, p= 0.002). The rich households have good relations with local administrators who were managing the forest during the imperial periods before the forest was gazetted in 1984. This relationship and local acceptance privileged them to get more *J. procera* wood. This manipulative use right and access to the state forest gave the rich households the opportunity to extract high value trees from the state forest. Sometimes they also buy from those who smuggle from the state forest in an 'invisible market'. Thus, their purchasing power i.e. financial capability also gave the rich

the chance to get more of the high value woods from various sources. Thus, the rich had better access to this wood type than the poor. Such opportunities altogether gave the rich households to have 69.5% of the construction wood from the state forest as compared to 50.7 and 51.5% for the medium and poor households respectively. The same factors mentioned above also have resulted in the extraction of 15.4-m^3 house construction wood per household by the rich households as compared to 5.7 and 3.3 m^3 by the medium and poor households respectively. Our findings agree with Mamo et al. (2008), Adhikari et al. (2004), Escobal et al. (2003), and Cavendish (2000) who stated that rich households extract larger quantities of resources as compared to the medium and poor households. Regarding relative extraction (i.e. the proportion of construction wood extracted from forest as compared to the total construction wood used), we still found that rich households are very dependent on the state forest than the others, which disagrees with the ideas of the above authors stating the poor households drive larger proportions of their forest products demands from free access forest resources than the rich and medium ones. Rather our findings agree with Narain et al. (2008) who found that the reliance on forests for construction wood in India increases with income level.

E. camaldulensis and *C. lusitanica* are common among the poor farm households. *E. globulus* is almost equally used despite the wealth status difference. Wells et al. (1998) also reported that poorer households in Mali often tend to use ordinary wood, which are of low quality for construction. This is also evidenced by the high volume of *C. lusitanica* wood (a low quality wood as compared to the other three species) used by the poor households in Suba area. The poor are less selective as compared to the other groups indicating that they use any wood available (Fig. 1).

Proximity to the state forest (the major source of wood supply for the community formerly) significantly influenced the total wood consumption of *C. lusitanica*, *E. camaldulensis* and *E. globulus* (p = 0.038, p < 0.001, and p = 0.007 respectively). With increasing distance from the state forest, the composition of *E. camaldulensis* in houses increased (r = 0.78, p < 0.001). This is influenced by the altitudinal location of the farm households that influences the growth performance of the species. The state forest is situated on an elevated area ranging from 2300–2900 m a.s.l., which makes it unfavorable for the growth of *E. camaldulensis*. The farther away farm households are located at lower altitude (< 2300 m) enhancing the use of this tree species. That is why an increase of *E. camaldulensis* wood was observed with increasing distance from the forest. The *C. lusitanica* and *E. globulus* wood were found to decrease (r = -0.34, p = 0.04 and r = –0.42, p = 0.01 respectively) with increasing distance from the state forest. The two major reasons for the decrease are: (1) the state forest is the major source of *C. lusitanica* as the farmers do not have any tree of this species on their farms readily available for construction purpose; (2) the farther the distance from the forest is, the lower the altitude becomes. At such altitudes *E. globulus* performs poorly.

Factors influencing house floor space and its wood consumption

Wealth class of the household

It was observed that wealth status has a very significant positive correlation (r = 0.54, p= 0.001 and r = 0.57, p < 0.001) with house floor space and construction wood consumption respectively. Rich households do have large houses and consume large volume of wood. The mean comparison also showed that there is a significant difference (p= 0.003 and p= 0.001) among the farmers' in house floor space and wood consumption respectively due to wealth status difference (Fig. 2).

The total floor space was found to be the strongest variable explaining the house construction wood consumption of the farm households (r = 0.85, p < 0.001), indicating an increase in construction wood consumption with increasing house floor space. Floor space is also easy to measure for predicting the wood consumption.

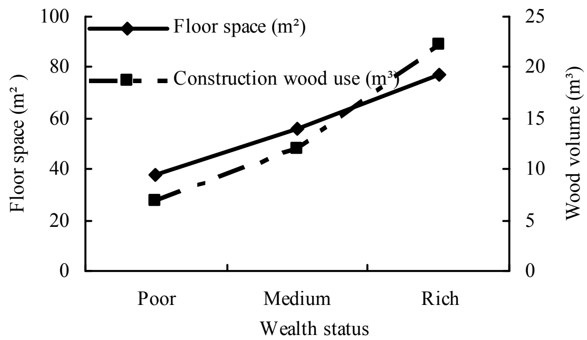

Fig. 2 House floor space and wood consumption across wealth classes

Family size

The family size of households had a significant positive correlation (r = 0.37, p = 0.025) with the floor space of house owned. Larger households normally need large living spaces, compared to smaller households. On the other hand, large families (i.e. in terms of number of people in the family) have sufficient labor force to build the living house they require by extracting wood from various sources. Adhikari et al. (2004) also described that larger families require more resources (including construction wood) which needs more labor, and often fulfilled by household members.

Table 5. Model summary and parameter estimates for floor space estimation

Equation	Model summary					Parameter estimates
	R^2	F	df_1	df_2	Sig.	b_1
Predicted floor space (m^2) = (Family size)$^{2.26}$	0.94	542.79	1	35	0.00	2.26

As described above, family size is the strongest descriptor of house floor space. Thus, a model was estimated by using the regression curve estimation through the origin. Constants were not included in the model because no family size means no house. The developed model explained 94% of the variation in house

floor space due to variability in family size. The model was indicated to be fit ($F_{(1,35)}$ = 542.79, $p < 0.001$), (Table 5).

The family size has also a highly significant positive correlation (r = 0.45, p = 0.006) with total house construction wood consumption. As shown above the house floor space increases with family size and hence the wood consumption increases.

As the male members of a household increases, wood consumption for house construction increases (r = 0.35, p = 0.038). This is due to the social and cultural setup of the community where the responsibility of the males is to take care of the construction of houses, farming and cattle keeping in the fields, while the females are responsible for the feeding the family, homegarden care, fuelwood collection and sanitation of residence areas. Thus, males are very important for a family to have a large house composed of strong woods.

The future of house construction wood and foreseeable actions

The group discussion showed that *J. procera* and *C. lusitanica* and half the *E. globulus* wood were entirely obtained from the state forest (making altogether 59.5% of house construction wood) while *E. camaldulensis* wood is totally obtained from farmers' tree-growing practices. Thus, from the average construction wood consumption of 13.7 m^3 per household, 8.1 m^3 has been fulfilled by the state forest. The rest of the wood is obtained from small-scale woodlots, boundary tree growing, purchasing and illegal cutting. Now the extraction from the state forest is entirely banned following the demarcation of the state forest, which limited the availability of *J. procera*, *C. lusitanica* and partly of *E. globulus* woods. *J. procera* is even nationally banned from any kinds of use after being declared 'endangered species'. In general, the 59.5% supply is no more available for house construction. In view of this, the farmers to alleviate the forthcoming scarcity could adopt the following options.

(1) *Use of abandoned lands for tree growing*: Since the possibilities to get *J. procera* and *C. lusitanica* are very limited, the community has to divert towards growing *E. globulus* in the higher altitudes and *E. camaldulensis* in the lower altitudes. These two species are known to grow even in abandoned lands with minimal care. This calls for attention that the lands, which are already abandoned due to poor productivity, should be planted with trees. Florentine et al. (2004) also suggested that converting degraded lands like pasturelands into secondary forests could be a means of increasing forest cover from which forest products could be extracted.

(2) *Promotion of agroforestry technologies on private lands and degraded lands*: farm boundaries and roadsides could be grown with trees at least to provide minor house construction woods like *Maagara* and *Axanaa*. This also increases the land use efficiency because most of the farm borders are empty without any trees. On the other hand, trees like *Grevillea robusta* A. Cunn. ex R.Br., *Acacia decurrens* (Wendl.) Willd., *Acacia mearnsii* De Wild. and *Pinus patula* Schiede & Deppe, are able to grow on poor soils and produce various types of construction wood and should be promoted through agroforestry technologies. *G. robusta* can also be a fodder for animals and its branches serve as fuelwood (Dharani 2002). Thus, growing such multipurpose tree species can minimize the scarcity of wood products. *A. deccurens* and *A. mearnsii* are other potential trees to be planted to tackle the problem. Both can grow on degraded soils at medium altitudinal ranges except that the former should not be exposed to wind due to its shallow root morphology. The farmers can also plant *P. patula*, which grows from 1 400–3 000 m above sea level (Gillespie 1992), for production of optimally strong construction wood. It should be grown on abandoned lands because the litter accumulation rate is reported to be higher than the decomposition rate (Dames et al. 1998). However, the high litter production could be an advantage for using the litter for cooking and heating.

(3) *Establishment of community silvopasture*: the communal ownership of grazing lands in Suba area is an opportunity to establish community silvopasture in which timber species like *G. robusta* can be grown for providing construction wood. This increases the land use efficiency and enables them to manage two production systems on the same piece of land, thereby increasing the income from the same land unit (White 2005; Stainback et al. 2004; Vishwanatham et al. 1999). The incorporation of trees in to the pastureland also reduces the foraging energy of livestock (White 2005), which altogether increase their productivity. The planted trees should be protected against browsing and trampling effect of grazing animals until they grow above livestock reaching height. This can be done by avoiding direct grazing in the parts of the pastureland planted with trees while freely using the unplanted areas. Once the trees grow above the livestock reaching height, animals can be allowed to graze inside the planted area. To reduce the browsing effect, it is also possible to transplant grown saplings. The pasturelands boundary can also be planted with other timber tree species.

(4) *A shift to the use of local materials*: As the availability of construction wood is getting scarcer, there is a potential to use clay or soil bricks for building the house walls. This can drastically reduce the wood consumption by 78.1% (i.e. replacing the *Falaxaa* and *Dhaabaa*, which constitute 54.8 and 23.5% of houses respectively). Such usage of local materials greatly reduces the impact of wood resources scarcity on the environment and also reduces the energy required for house construction (Morel et al. 2001). However, the farmers should be trained and provided with the necessary equipments to independently progress with the production.

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References

Adhikari B, Falco SD, Lovett JC. 2004. Household characteristics and forest dependence: evidence from common property forest management in Nepal.

Ecological Economics, **48**: 245–257.

Aregu L, Demeke F. 2006. Socio-economic survey of Arba-Minch riverine forest and woodland. *Journal of the Drylands*, **1** (2): 194–205.

Banks DI, Grippin NJ, Shackleton CM, Shackleton SE, Mavrandonis JM. 1996. Wood supply and demand around two rural settlements in a semi-arid savanna, South Africa. *Biomass and Energy*, **11** (4): 319–331.

Cavendish W. 2000. Empirical irregularities in the poverty-environment relationship of the rural households: evidence from Zimbabwe. *World Development*, **28**: 1979–2000.

CSA (Central Statistical Authority of Ethiopia). 1996. *Statistical report on housing characteristics of Oromiya regional state*. Addis Ababa, Ethiopia: Central Statistical Authority, p. 276.

Dames JF, Scholes MC, Starker CJ. 1998. Litter production and accumulation in *Pinus patula* plantations of the Mpumalanga Province, South Africa. *Plant and Soil*, **203**: 183–190.

Dharani N. 2002. *Field guide to common trees and shrubs of East Africa*. Cape Town, South Africa: Struik Publishers, p. 320.

Duguma LA, Hager H, Gruber M. 2009a. The community–state forest interaction in Menagesha Suba area, Ethiopia: the challenges and possible solutions. *Forests*, *Trees and Livelihoods*, **19**: 111–128.

Duguma LA, Hager H. 2009b. Forest products scarcity perception and response by tree planting in the rural landscapes: farmers' views in central highlands of Ethiopia. *Ekológia* (*Bratislava*), **28** (2): 158–169.

EARO (Ethiopian Agricultural Research Organization). 2002. *Strategies for forestry research*. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization, p. 137.

Escobal J, Aldana U. 2003. Are nontimber forest products the antidote to rainforest degradation? Brazil nut extraction in Madre De Dios, Peru. *World Development*, **31**: 1873–1887.

Florentine SK, Westbrooke ME. 2004. Restoration on abandoned tropical pasturelands – do we know enough? *Journal of Nature Conservation*, **12**: 85–94.

Forest Service British Columbia. 2007. *Scaling manual*. British Columbia, Canada: Forest Service British Columbia, p. 492.

Gillespie AJR. 1992. *Pinus patula Schiede and Deppe. Patula pine. Pinaceae. Pine family*. Washington DC: USDA Forest Service, Southern Forest Experiment Station, Institute of Tropical Forestry, p. 5.

Jagger P, Pender J. 2003. The role of trees in the sustainable management of less-favored lands: the case of eucalyptus in Ethiopia. *Forest Policy and Economics*, **5**: 83–95.

Mamo G, Sjaastad E, Vedeld P. 2008. Economic dependence on forest resources: a case from Dendi district, Ethiopia. *Forest Policy and Economics*, **9**: 916–927.

Morel JC, Mesbah A, Oggero M, Walker P. 2001. Building houses with local materials: means to drastically reduce the environmental impact of construction. *Building and Environment*, **36**: 1119–1126.

Narain U, Gupta S, Veld K. 2008. Poverty and resources dependence in rural India. *Ecological Economics*, **66**: 161–176.

SPSS Inc. 2006. Statistical Packages for Social Sciences for Windows. Release 15.0.0. Chicago, SPSS Inc.

Stainback GA, Alavalapati JRR. 2004. Restoring longleaf pine through silvopasture practices: an economic analysis. *Forest Policy and Economics*, **6**: 371–378.

Thomas I, Bekele M. 2003. *Role of planted forest and trees outside forests in sustainable forest management:* Republic of Ethiopia country case study. Working paper FP/29E. Rome, Italy: FAO, p. 57.

Tiwari P. 2001. Housing and development objectives in India. *Habitat International*, **25**: 229–253.

United Nations. 1948. Universal declaration of human rights. Paris, France: United Nations General Assembly. Retrieved September 23, 2008 from http://en.wikisource.org/wiki/Universal_Declaration_of_Human_Rights

Vishwanatham MK, Samra JS, Sharma AR. 1999. Biomass production of trees and grasses in a silvopasture system on marginal lands of Doon Valley of north-west India. 1. Performance of tree species. *Agroforestry Systems*, **46** (2): 181–196.

Wall DM, Wells J, Uhde M, Sy A. 1998. The market for construction wood in Mopti, Mali. *Habitat International*, **22** (4): 523–536.

Wells J. 1995. Population, settlements and the environment: the provision of organic materials for shelter: a literature review. *Habitat International*, **19** (1): 73–90.

Wells J, Haddar F, Uhde M, Sy A. 1998. Shelter provision in the context of deforestation: some evidence from Mali. *Habitat International*, **22** (4): 463–475.

White L. 2005. *Silvopasture literature review*. Canada: Saskatchewan Forest Centre, p. 36.